

**Michigan Department of Environmental Quality
Water Division
July 2004**

**Total Maximum Daily Load for *Escherichia coli* for
Duff Creek
Sanilac County**

INTRODUCTION

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations (CFR), Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting water quality standards (WQS). The TMDL process establishes the allowable loadings of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. TMDLs provide states a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify the allowable levels of *Escherichia coli* (*E. coli*) that will result in the attainment of the applicable WQS in Duff Creek, a tributary to the south branch of the Cass River, located in Sanilac County, Michigan.

PROBLEM STATEMENT

This water body was first placed on the Section 303(d) list in 2002. This TMDL listing addresses approximately six miles of stream in the vicinity of Marlette. The TMDL reach is on the 2002 Section 303(d) list as:

DUFF CREEK

WBID#: **210406A**

County: Sanilac

HUC: 4080205

Size: 6 M

Location: S. Br. Cass River u/s to vicinity of Marlette.

Problem: **Untreated sewage discharges, pathogens (Rule 100);
Macroinvertebrate community.**

TMDL YEAR(s): 2004

RF3RchID: 4090001 1415.00

Duff Creek (Figure 1) was placed on the Section 303(d) list due to impairment of recreational uses as indicated by the presence of elevated levels of *E. coli* (Creal and Wuycheck, 2002). Monitoring data collected by the Michigan Department of Environmental Quality (MDEQ) in 2002, documented exceedances of the WQS for *E. coli* at all sampling locations during the total body contact recreational season of May 1 and October 31 (Tables 1 and 2).

NUMERIC TARGET

The impaired designated use addressed by this TMDL is total body contact recreation. Rule 100 of the Michigan WQS requires that this water body be protected for total body contact recreation from May 1 to October 31. The target levels for this designated use are the ambient *E. coli* standards established in Rule 62 of the WQS as follows:

R 323.1062 Microorganisms.

Rule 62. (1) All waters of the state protected for total body contact recreation shall not contain more than 130 *E. coli* per 100 milliliters (ml), as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples taken during five or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of three or more samples taken at representative locations within a defined sampling area. At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 ml. Compliance shall be based on the geometric mean of three or more samples taken during the same sampling event at representative locations within a defined sampling area.

In addition, sanitary wastewater discharges have an additional target:

Rule 62. (3) Discharges containing treated or untreated human sewage shall not contain more than 200 fecal coliform bacteria per 100 ml, based on the geometric mean of all of five or more samples taken over a 30-day period, nor more than 400 fecal coliform bacteria per 100 ml, based on the geometric mean of all of three or more samples taken during any period of discharge not to exceed seven days. Other indicators of adequate disinfection may be utilized where approved by the Department.

Sanitary wastewater discharges are considered in compliance with the WQS of 130 *E. coli* per 100 ml if their National Pollutant Discharge Elimination System (NPDES) permit limit of 200 fecal coliforms per 100 ml as a monthly average is met. This is assumed because *E. coli* are a subset of fecal coliform (American Public Health Association, 1995). Fecal coliform are substantially higher than *E. coli* (Whitman, 2001) when the wastewater of concern is sewage. Therefore, it can reasonably be assumed that there are less than 130 *E. coli* per 100 ml in the effluent when the point source discharge is meeting its limit of 200 fecal coliform per 100 ml.

For this TMDL, the WQS of 130 *E. coli* per 100 ml as a 30-day geometric mean and 300 *E. coli* per 100 ml as a daily maximum are the target levels for the TMDL reach from May 1 to October 31. As previously stated, the 2002 monitoring data indicated exceedances of WQS at all locations sampled. The station with the highest concentration is located immediately downstream of Marlette at Boyne Road. Duff Creek has minimal flow at this location (Table 3).

DATA DISCUSSION

Duff Creek was sampled at four stations (Figure 1). The highest observed *E. coli* concentrations in Duff Creek were located at the Boyne Road station (DF-6) (Table 1 and Figure 2). Thirty-day geometric mean concentrations at this station exceeded 1,000 *E. coli* per 100 ml for the last six weeks of sampling while daily geometric mean concentrations exceeded 2,000 *E. coli* per 100 ml nine times during the sampling season. *E. coli* concentrations in Duff Creek ranged from 86 *E. coli* per 100 ml in July at Decker Road (DF-5) to 2,780 *E. coli* per 100 ml in September at Boyne Road (DF-6). In general, *E. coli* concentrations tended to decrease slightly at Decker Road (DF-5) as compared to upstream Boyne Road (DF-6) while the remaining downstream stations, French Line Road (DF-4) and Germania (DF-2), exceeded the thirty-day geometric mean on all but three sampling events. With exception of Decker Road (DF-5), daily geometric mean concentrations were greater than 1,000 *E. coli* per 100 ml at least one time during the sampling season at all locations.

The South Branch of the Cass River was also sampled at two locations. Thirty-day geometric mean *E. coli* concentrations ranged from 61 *E. coli* per 100 ml at French Line Road (DF-3) in June to 549 *E. coli* per 100 ml at Walker Road (DF-1) (Table 2, Figure 3). Both stations

experienced sporadic exceedances of the daily geometric mean, with the highest concentration of 2,300 *E. coli* per 100 ml occurring in September at Walker Road.

The 2002 Section 303(d) listing for Duff Creek was approximately six miles of stream in the vicinity of Marlette. Based on a review of the listing and the 2002 monitoring data, the listed TMDL reach was modified in the 2004 listing to include approximately one mile of the south branch of the Cass River (Wolf and Wuycheck, 2004).

SOURCE ASSESSMENT

The official listed reach for Duff Creek is the confluence with the south branch of the Cass River upstream approximately six miles to the vicinity of Marlette. Based on a review of the 2002 data, the modified listed reach will include approximately one mile of the south branch of the Cass River, from Walker Road upstream to French Line Road. The municipalities in the modified reach for Duff Creek and the south branch of the Cass River include Marlette Township, Flynn Township, Elmer Township, and the city of Marlette (Figure 1). Table 4 shows the distribution of land for each municipality.

The primary pathogen sources for this water body are typical of mixed suburban and agricultural land uses. The reason for the listing was primarily due to problems with the city of Marlette wastewater collection and treatment system bypasses resulting in raw sewage releases to surface waters. The collection system was originally constructed as a combined sanitary sewer system, carrying storm water runoff and sanitary sewage in the same pipe. This antiquated system of combined sewers allowed a large amount of rain water to enter the wastewater treatment system. In addition, the aging collection system succumbed to structural failures, which permitted additional rain water and groundwater to enter the system. This inflow and infiltration, occurring mainly during and after wet weather events, produced flows in excess of the wastewater treatment plant (WWTP) design capacity. The WWTP outdated design, aging equipment, and inadequate sizing further contributed to the city's operation and maintenance problems (MDEQ, 1999). The combined system was separated in 1995, but the WWTP has continued to experience raw sewage bypasses during wet weather events. One sanitary sewer overflow was reported in February 2002.

Consistent dry weather exceedances of the *E. coli* standards at Boyne Road (DF-6) indicate two potential sources of *E. coli*: illicit connections upstream of the WWTP discharge and/or inadequate disinfection of the Marlette WWTP effluent. The average flow of Duff Creek during the periods of greatest exceedance of the daily geometric mean (June, August, and September) is 0.1 cubic feet per second (cfs) or less (Table 3). The permitted flow for the WWTP is 0.62 million gallons per day (1.0 cfs), therefore Duff Creek is effluent dominated (Table 3). Sample results for *E. coli* downstream of the WWTP could be indicative of the problems with the Marlette WWTP ultraviolet disinfection system. The WWTP has been cited for leaks in the ultraviolet disinfection system chamber and problems with the Fecal Coliform analytical procedure and calculations (Suuppi, 2003 and 2004). Corrective actions are underway. The concentration of *E. coli* in a stream with low flow can also be greatly influenced by illicit connections. Several PVC pipes entering the stream channel indicate homes in the immediate area of Boyne Road are another likely source of *E. coli* exceedances at this location.

Approximately 70% of the watershed is categorized as agricultural (Purdue, 2003). The watershed is extensively tiled for drainage, and land application of manure is another possible source of *E. coli* to the Duff Creek TMDL watershed. Field studies have shown significant transport of enteric bacteria through tile drainage systems under all manure application protocols and environmental conditions (Jamieson, et al., 2002).

In an effort to determine possible sources of *E. coli* to Duff Creek, the MDEQ collected two samples for Deoxyribonucleic acid (DNA) ribotyping analysis at Boyne Road on August 7 and August 27, 2003. These samples were representative of dry weather conditions, no precipitation in the preceding 24 hours. This is a relatively new technology that extracts DNA from *E. coli* isolates and compares the DNA to a library of known source isolates. The results from the sample collected August 7, 2003, indicated three isolates of nonhuman origin and two isolates indeterminate (note that these sample results may be compromised due to difficulties in the shipping process before arriving at the laboratory for analysis) (Table 5). Another sample collected August 27, 2003, at Boyne Road, indicate that Duff Creek contained *E. coli* of both human (one of five isolates) and nonhuman origin (four of five isolates) (Table 6). A possible explanation for the isolates of nonhuman origin found at station DF-6, which is located just downstream of the WWTP discharge, is the disposal of pet waste via toilets in the home, thus introducing the waste to the sanitary system. Another possible source is from wild animals (i.e. raccoons and rats) living in the storm sewers. *E. coli* from wild animal waste may be contributing to the problem in Duff Creek during dry or non-runoff conditions due to groundwater infiltrating the storm sewer system.

Currently, there are five NPDES permitted discharges to Duff Creek in the TMDL reach (Table 7); one individual permit, one Notice of Coverage, and four industrial storm water permits. The Marlette WWTP (MI0021024) is permitted to discharge treated human waste. The industrial storm water discharges are not considered to contain treated or untreated human sewage or animal waste; therefore, they are not considered a significant source of *E. coli* to the Duff Creek TMDL watershed. The one Notice of Coverage permit involves earth work in the TMDL watershed.

LINKAGE ANALYSIS

Determining the link between the *E. coli* concentrations in Duff Creek and the potential sources is necessary to develop the TMDL. This link provides the basis for estimating the total assimilative capacity of the creek and any needed load reductions. For this TMDL, the major loadings of pathogens appear to enter Duff Creek during dry weather. Potential sources include the WWTP due to inadequate effluent treatment, illicit connections and animal waste from the storm sewers. Wet weather sources influenced by the land use in the watershed (i.e., unpermitted stormwater runoff from the city of Marlette to Duff Creek and agricultural runoff to both Duff Creek and the South Branch of the Cass River), are other potential sources of *E. coli*.

The guiding water quality management principle used to develop the TMDL was that compliance with the numeric pathogen target in Duff Creek and the South Branch of the Cass River depends on the control of *E. coli* from wet and dry weather sources. If the *E. coli* inputs can be controlled to meet the numeric standards, then total body contact recreation in Duff Creek and the South Branch of the Cass River will be restored and protected.

TMDL DEVELOPMENT

The TMDL represents the maximum loading that can be assimilated by the water body while still achieving WQS. As indicated in the Numeric Target section, the targets for this pathogen TMDL are the thirty-day geometric mean WQS of 130 *E. coli* per 100 ml and daily geometric mean of 300 *E. coli* per 100 ml. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the environmental conditions that will be used when defining allowable levels. Many TMDLs are designed around the concept of a "critical condition." The "critical condition" is defined as the set of environmental conditions that, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical conditions for the control of point sources in Michigan are given in R 323.1082 and R 323.1090.

In general, the lowest monthly 95% exceedance flow for streams is used as a design condition for point source discharges. However, for pathogens in point source discharges of treated or untreated human sewage, levels are restricted to a monthly average limit of 200 Fecal coliform per 100 ml regardless of stream flow. Therefore, the design stream flow is not a critical condition for determining the allowable loading of pathogen for WWTPs. In addition, sources of pathogens to Duff Creek arise from a mixture of wet and dry weather-driven nonpoint sources. For these sources, there are a number of different allowable loads that will ensure compliance, as long as they are distributed properly throughout the watershed.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). For *E. coli*, however, mass is not an appropriate measure, and the USEPA allows pathogen TMDLs to be expressed in terms of organism counts (or resulting concentration) (USEPA, 2001). Therefore, this pathogen TMDL is concentration-based consistent with R 323.1062, and the TMDL is equal to the target concentration of 130 *E. coli* per 100 ml as a 30-day geometric mean and daily geometric mean of 300 *E. coli* per 100 ml in all portions of the TMDL reach for each month of the recreational season (May through October). Expressing the TMDL as a concentration equal to the WQS ensures that the WQS will be met under all flow and loading conditions; therefore, a critical condition is not applicable for this TMDL.

ALLOCATIONS

TMDLs are comprised of the sum of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly within the WLA or LA, or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. This pathogen TMDL will not be expressed on a mass loading basis and is concentration-based consistent with USEPA regulations in 40 CFR, Section 130.2(i).

WLAs

There are a total of five permitted point source discharges to the listed reach of Duff Creek and the South Branch of the Cass River. The storm water permitted discharges are not considered significant sources of *E. coli* to Duff Creek due to Best Management Practices (BMPs) required in the permit. The Notice of Coverage involves earth work in the watershed and, due to the nature of the permit, is not considered a significant source of *E. coli* to Duff Creek. The Notice of Coverage expires in 2006. The permit for the Marlette WWTP authorizes the discharge of treated human waste to Duff Creek and has a fecal coliform limit. The WWTP is considered in compliance with the WQS of 130 *E. coli* per 100 ml if their NPDES permit limit of 200 fecal coliform per 100 ml as a monthly average is met. The WLA for the Marlette WWTP, including the storm water permits, is equal to 130 *E. coli* per 100 ml during the recreational season between May 1 and October 31.

LAs

Because this TMDL is concentration-based, the LA is equal to 130 *E. coli* per 100 ml. This is based on the assumption that all land, regardless of use, will be required to meet the WQS.

Therefore, the relative responsibility for achieving the necessary reductions of bacteria and maintaining acceptable conditions will be determined by the amount of land under the jurisdiction of the local unit of government in the watershed. This TMDL reach is located in Marlette Township, Flynn Township, Elmer Township, and the city of Marlette.

MOS

This section addresses the incorporation of an MOS in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality, including the pollutant decay rate if applicable. The MOS can be either implicit (i.e., incorporated into the WLA or LA through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS because no rate of decay was used. Pathogen organisms have a limited capability of surviving outside of their hosts and a rate of decay could be developed. However, applying a rate of decay could result in an allocation that would be greater than the WQS, thus no rate of decay is applied in order to provide for a greater protection of water quality. The MDEQ has determined that the use of the WQS of 130 *E. coli* per 100 ml for the WLA and LA is a more conservative approach than developing an explicit MOS and accounts for the uncertainty in the relationship between pollutant loading and water quality based on available data and the assumption to not use a rate of decay. Applying the WQS to be met under all flow conditions also adds to the assurance that an explicit MOS is unnecessary.

SEASONALITY

Seasonality in the TMDL is addressed by expressing the TMDL in terms of a total body contact recreation season that is defined as May 1 through October 31 by R 323.1100 of the WQS. There is no total body contact during the remainder of the year primarily due to cold weather. In addition, because this is a concentration-based TMDL, WQS will be met regardless of flow conditions in the applicable season.

MONITORING

In 2002, pathogens were monitored weekly at a total of six stations; four on Duff Creek and two on the south branch of the Cass River from May through September. Future monitoring will take place as part of the five-year rotating basin monitoring. When these results indicate that the water body may be meeting WQS, sampling will be conducted at the appropriate frequency (as defined in the numeric target section) to determine if the 30-day geometric mean value of 130 *E. coli* per 100 ml and 300 *E. coli* per 100 ml as a daily maximum are being met.

REASONABLE ASSURANCE ACTIVITIES

The Marlette WWTP is under a fourth amended consent judgment with the MDEQ. The consent judgment directs the city of Marlette to construct a 30-inch main sewer, a three million gallon retention basin, and upgrade the WWTP. The resulting upgrades will be beneficial to Duff Creek because future bypasses will be reduced or eliminated. The Marlette WWTP is responsible for meeting their NPDES permit limits for fecal coliform. Problems with the ultraviolet disinfection system have been corrected and the analytical procedures and calculation errors have been addressed. Corrected DMRs will be submitted to the MDEQ for their review. If the WWTP is found to be in noncompliance, they will be responsible for submitting a plan to bring the plant back into compliance with their NPDES permit limits. The city of Marlette has also committed to investigating potential illicit connections to their storm

sewer system. This investigation will include submitting a plan of action to the MDEQ to address the issue.

There are no current watershed projects; however, implementation of a Comprehensive Nonpoint Source Watershed Plan for Duff Creek occurred from 1992-1995. The objectives of the plan were to identify nonpoint sources of pollution and implement BMPs. Duff Creek was identified as a flood-prone system and grass filter strips were utilized to control agricultural runoff and sediment; a practice known to reduce the amount of sediment and pathogens that enter waterways (Durham, 2002).

Prepared by: Christine Alexander, Aquatic Biologist
Surface Water Quality Assessment Section
Water Division
Michigan Department of Environmental Quality
July 12, 2004

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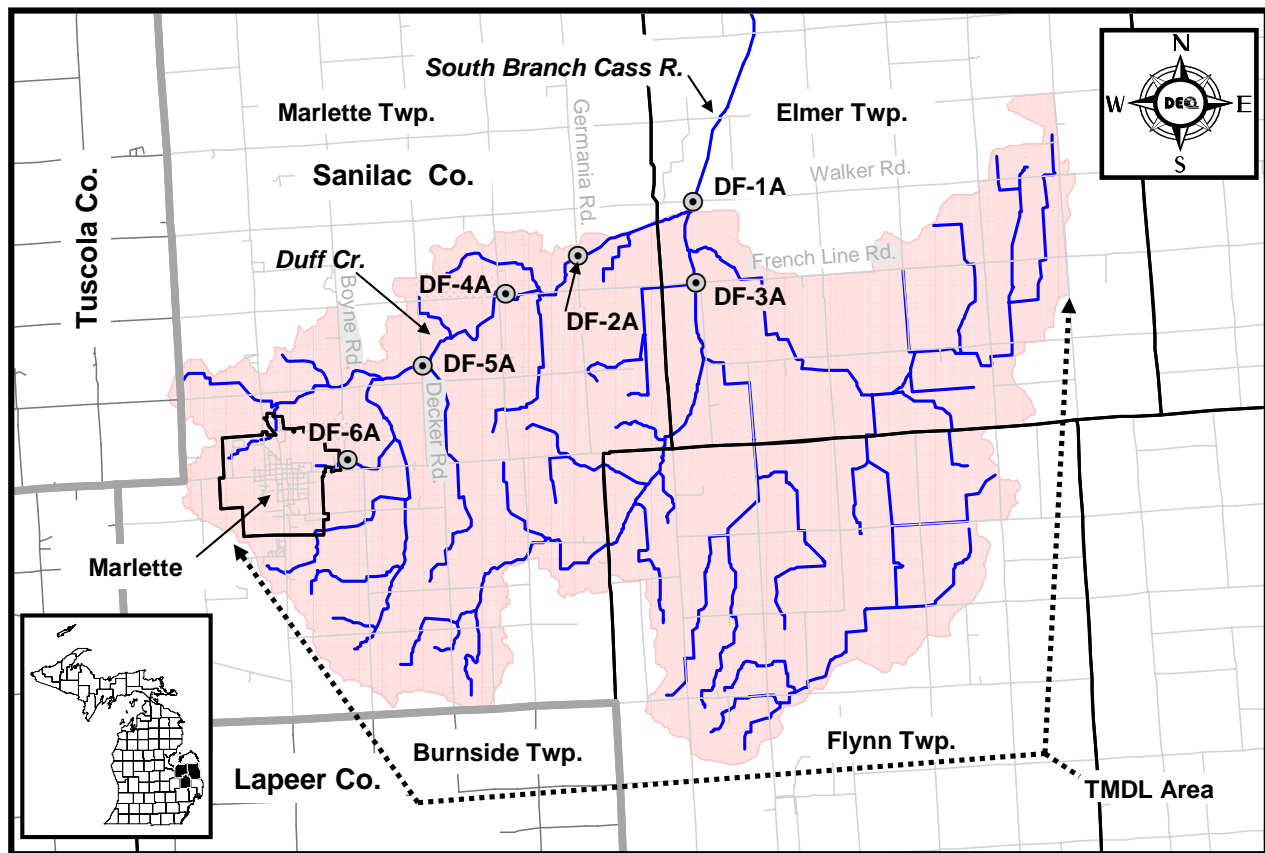


Figure 1. Duff Creek *E. coli* sampling locations, vicinity of Marlette, Michigan, 2002. Shaded areas represent the TMDL watershed.

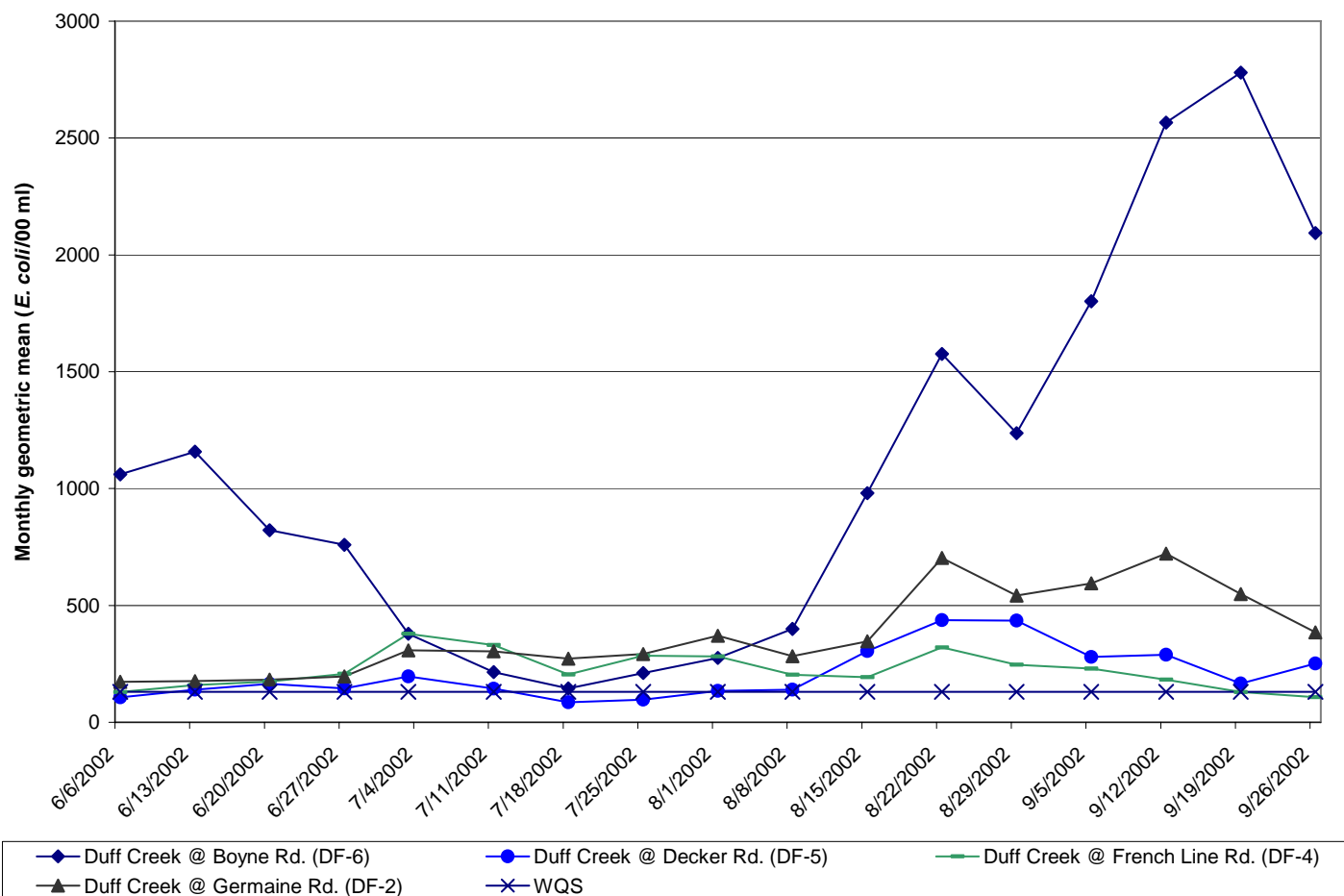


Figure 2. Thirty-day Geometric mean for *E. coli* in Duff Creek in the vicinity of Marlette, Sanilac County, Michigan, 2002.

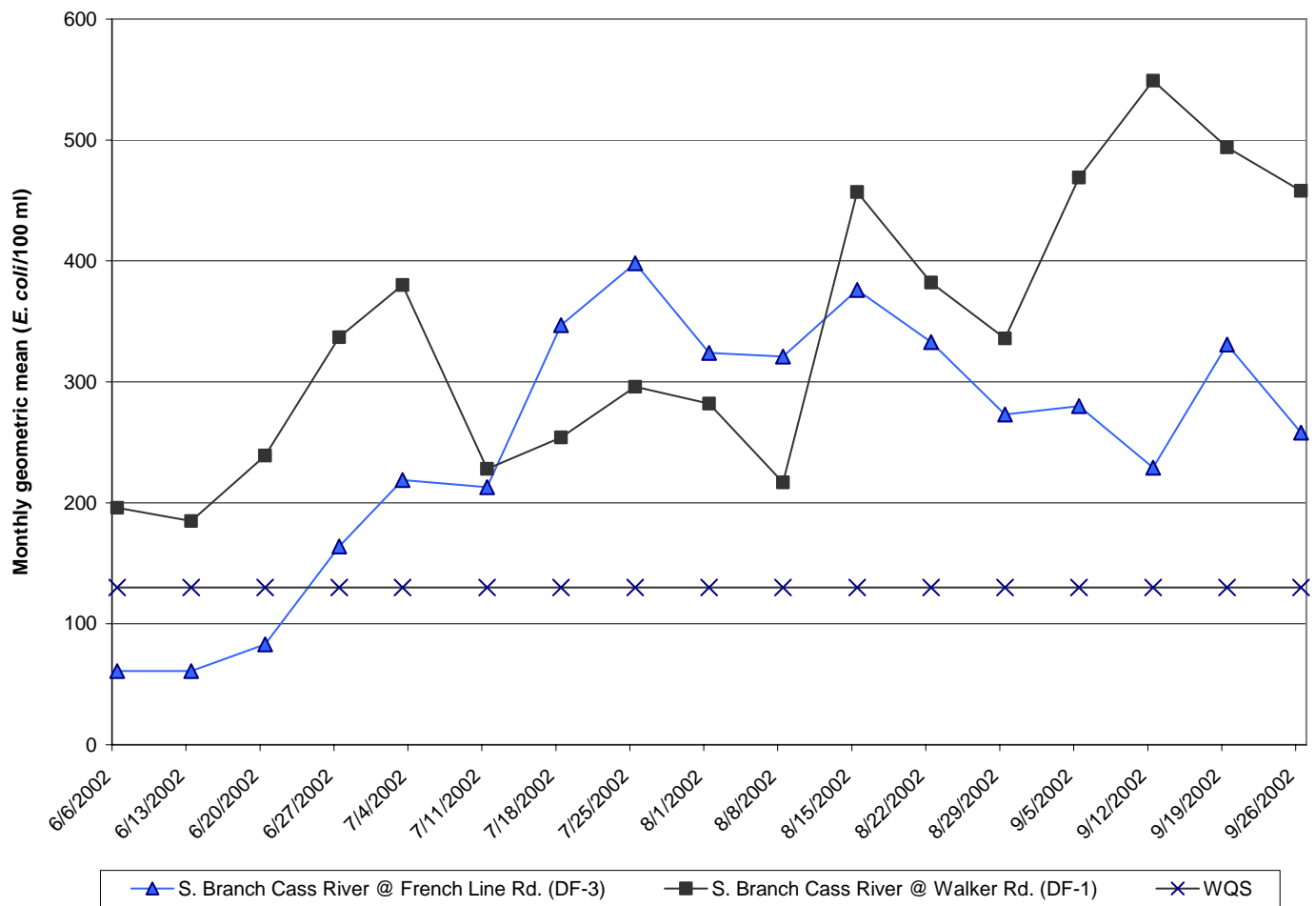


Figure 3. Thirty-day Geometric mean for *E. coli* in the South Branch of the Cass River, Sanilac County, Michigan, 2002.

Table 1. MDEQ 2002 *E. coli* monitoring data for Duff Creek (*E. coli*/100 ml) in the vicinity of Marlette. Shaded areas indicate exceedances of the Water Quality Standards. Data are presented upstream to downstream.

	Duff Creek @ Boyne Road (DF-6)			Duff Creek @ Decker Road (DF-5)			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Weather Data
5/10/2002	800	1048	---	20	68	---	sunny, 50°
	720			80			
	2000			200			
5/16/2002	5200	6022	---	80	115	---	rain, 65°
	7000			120			
	6000			160			
5/23/2002	20	197	---	160	221	---	sunny, 65°
	760			260			
	500			260			
5/30/2002	2400	2194	---	260	85	---	sunny, 70°
	2200			120			
	2000			20			
6/6/2002	480	493	1061	80	92	106	clear, 70°
	520			120			
	480			80			
6/13/2002	2800	1626	1158	340	267	140	overcast, 65°
	1600			280			
	960			200			
6/20/2002	800	1086	822	280	266	165	humid, 80°
	1000			240			
	1600			280			
6/27/2002	320	132	759	320	115	145	sunny, 75°
	20			240			
	360			20			

Table 1 continued (*E. coli*/100 ml).

	Duff Creek @ Boyne Road (DF-6)			Duff Creek @ Decker Road (DF-5)			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Weather data
7/3/2002	20	68	379	400	383	196	sunny, 85°
	800			1400			
	20			100			
7/11/2002	60	29	215	20	20	144	sunny, 75°
	20			20			
	20			20			
7/18/2002	920	228	145	20	20	86	overcast, 75°
	640			20			
	20			20			
7/25/2002	6200	7095	211	420	490	97	partly sunny, 70°
	6400			700			
	9000			400			
8/1/2002	2600	494	275	600	599	135	cloudy, 75°
	580			640			
	80			560			
8/8/2002	2000	445	400	520	451	140	sunny, 65°
	2200			520			
	20			340			
8/15/2002	5200	2564	981	720	989	305	cloudy, 75°
	1800			1400			
	1800			960			
8/22/2002	3000	2433	1576	300	122	437	rain, 75°
	3000			300			
	1600			20			

Table 1 continued (*E. coli*/100 ml).

	Duff Creek @ Boyne Road (DF-6)			Duff Creek @ Decker Road (DF-5)			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Weather data
8/29/2002	1800	2114	1237	400	480	435	sunny, 75°
	2600			420			
	2020			660			
9/5/2002	2000	3227	1801	120	66	280	sunny, 70°
	4000			20			
	4200			120			
9/12/2002	2400	2614	2566	500	526	289	sunny, 70°
	6200			560			
	1200			520			
9/19/2002	5200	3830	2780	600	62	166	sunny, 75°
	3000			20			
	3600			20			
9/26/2002	3200	589	2094	600	952	251	foggy, 65°
	400			2400			
	160			600			

Table 1 continued (*E. coli*/100 ml).

	Duff Creek @ French Line Road (DF-4)			Duff Creek @ Germania Road (DF-2)			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Weather data
5/10/2002	140	77	---	280	92	---	sunny, 50°
	160			20			
	20			140			
5/16/2002	140	104	---	740	390	---	rain, 65°
	80			400			
	100			200			
5/23/2002	100	167	---	160	137	---	sunny, 65°
	260			160			
	180			100			
5/30/2002	520	94	---	600	113	---	sunny, 70°
	80			20			
	20			120			
6/6/2002	280	287	129	400	282	173	clear, 70°
	280			200			
	300			280			
6/13/2002	440	226	160	60	99	176	overcast, 65°
	60			20			
	440			800			
6/20/2002	160	157	174	480	480	183	humid, 80°
	120			640			
	200			360			
6/27/2002	820	406	208	720	190	196	sunny, 75°
	240			480			
	340			20			

Table 1 continued (*E. coli*/100 ml).

	Duff Creek @ French Line Road (DF-4)			Duff Creek @ Germania Road (DF-2)			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Weather data
7/3/2002	2000	1887	379	2200	1097	308	sunny, 85°
	2400			600			
	1400			1000			
7/11/2002	20	145	331	1280	262	304	sunny, 75°
	700			700			
	220			20			
7/18/2002	20	20	204	20	57	272	overcast, 75°
	20			20			
	20			460			
7/25/2002	280	846	285	600	686	292	partly sunny, 70°
	1200			640			
	1800			840			
8/1/2002	200	383	282	740	622	370	cloudy, 75°
	440			580			
	640			560			
8/8/2002	120	369	203	1640	284	283	sunny, 65°
	700			20			
	600			700			
8/15/2002	100	113	193	660	718	346	cloudy, 75°
	40			560			
	360			1000			
8/22/2002	240	250	320	1840	1973	703	rain, 75°
	180			3600			
	360			1160			

Table 1 continued (*E. coli*/100 ml).

	Duff Creek @ French Line Road (DF-4)			Duff Creek @ Germania Road (DF-2)			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Weather data
8/29/2002	120	227	246	600	186	542	sunny, 75°
	540			20			
	180			540			
9/5/2002	180	275	230	3200	991	595	sunny, 70°
	320			380			
	360			800			
9/12/2002	400	117	183	680	748	722	sunny, 70°
	20			960			
	200			640			
9/19/2002	20	20	129	40	183	549	sunny, 75°
	20			240			
	20			640			
9/26/2002	140	96	107	200	333	385	foggy, 65°
	20			420			
	320			440			

Table 2. MDEQ 2002 *E. coli* monitoring data for the South Branch of the Cass River (*E. coli*/100 ml), Sanilac County, Michigan. Shaded areas indicate exceedances of the Water Quality Standard. Data are presented upstream to downstream.

	S. Branch of the Cass River @ French Line Road (DF-3)			S. Branch of the Cass River @ Walker Road (DF-1)			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Weather data
5/10/2002	360	52	---	140	363	---	sunny, 50°
	20			3420			
	20			100			
5/16/2002	20	55	---	40	78	---	rain, 65°
	60			100			
	140			120			
5/23/2002	40	36	---	80	99	---	sunny, 65°
	60			120			
	20			100			
5/30/2002	60	52	---	440	399	---	sunny, 70°
	20			240			
	120			600			
6/6/2002	120	157	61	220	259	196	clear, 70°
	180			220			
	180			360			
6/13/2002	120	52	61	360	271	185	overcast, 65°
	20			120			
	60			460			
6/20/2002	320	253	83	440	280	239	humid, 80°
	180			500			
	280			100			
6/27/2002	1040	1094	164	120	553	337	sunny, 75°
	1400			640			
	900			2200			

Table 2 continued (*E. coli*/100 ml).

	S. Branch of the Cass River @ French Line Road (DF-3)			S. Branch of the Cass River @ Walker Road (DF-1)			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Weather data
7/3/2002	240	219	219	800	727	380	sunny, 85°
	220			1200			
	200			400			
7/11/2002	320	137	213	20	20	228	sunny, 75°
	200			20			
	40			20			
7/18/2002	520	608	347	540	470	254	overcast, 75°
	600			400			
	720			480			
7/25/2002	500	501	398	700	599	296	partly sunny, 70°
	420			640			
	600			480			
8/1/2002	440	391	324	220	434	282	cloudy, 75°
	340			600			
	400			620			
8/8/2002	220	210	321	420	195	217	sunny, 65°
	300			880			
	140			20			
8/15/2002	300	300	376	1000	838	457	cloudy, 75°
	180			600			
	500			980			
8/22/2002	280	330	333	400	192	382	rain, 75°
	320			440			
	400			40			

Table 2 continued (*E. coli*/100 ml).

	S. Branch of the Cass River @ French Line Road (DF-3)			S. Branch of the Cass River @ Walker Road (DF-1)			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Weather data
8/29/2002	40	186	273	360	316	336	sunny, 75°
	380			440			
	420			200			
9/5/2002	480	446	280	2600	2300	469	sunny, 70°
	440			2600			
	420			1800			
9/12/2002	260	292	299	320	425	549	sunny, 70°
	320			500			
	300			480			
9/19/2002	560	498	331	560	498	494	sunny, 75°
	480			460			
	460			480			
9/26/2002	300	94	258	220	130	458	foggy, 65°
	20			100			
	140			100			

Table 3. Duff Creek average flows (cfs) at Boyne Road, Sanilac County, Michigan.

May	June	July	August	September	October
0.3	0.1	0.1	0	0	0

Table 4. Distribution of land for each municipality in the Duff Creek TMDL reach.

Municipality	Square Miles	Percent
Marlette Township	21.1	43
Flynn Township	13.8	28
Elmer Township	12.7	26
City of Marlette	1.5	3
TOTAL	49.1	100

Table 5. Discriminant Analysis of Ribotype Profiles of *E. coli* isolates from water sample received from Boyne Road (DF-6) on August 13, 2003.

Fecal coliform mpn [*] /100 ml	<i>E. coli</i> isolate number (5 colonies of cultured <i>E. coli</i> were analyzed)	Probable Source
1,100	1 2 3 4 5	Non-human Non-human Non-human Indeterminate** Indeterminate**

*mpn = most probable number of fecal coliforms in 100 mL of sample after 20 hrs of cultivation at 44.5 degrees Celcius.

**Two of the *E. coli* isolate DNA fingerprints were classified as indeterminate. The probable source of these *E. coli* isolates can either be human or animal.

Table 6. Discriminant Analysis of Ribotype Profiles of *E. coli* isolates from water sample received from Boyne Road (DF-6) on August 28, 2003.

Fecal coliform mpn [*] /100 ml	<i>E. coli</i> isolate number (5 colonies of cultured <i>E. coli</i> were analyzed)	Probable Source
> 2,400	1 2 3 4 5	Non-human Non-human Human Non-human Non-human

*mpn = most probable number of fecal coliforms in 100 mL of sample after 20 hrs of cultivation at 44.5 degrees Celcius.

Table 7. Permitted outfalls to the Duff Creek TMDL watershed in the vicinity of Marlette. Source: MDEQ, Water Division's NPDES Permit Management System.

Facility	Permit Number	Receiving Water	Latitude	Longitude
Marlette WWTP	MI0021024	Duff Creek	43.3283	-83.08
Sanilac Steel Inc.	MIR011423		43.34417	-83.0822
Eugene Welding Co.	MIR011637		43.3222	-83.07722
DGP Inc – Marlette	MIS310017		43.32306	-83.0822
Notice of Coverage	MIR105358	---	---	---